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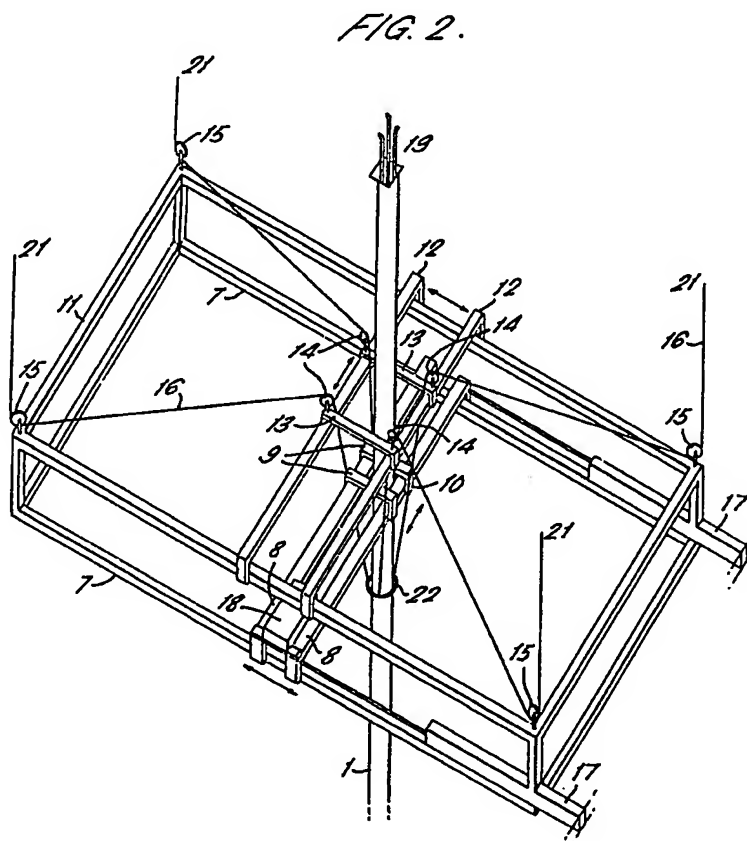
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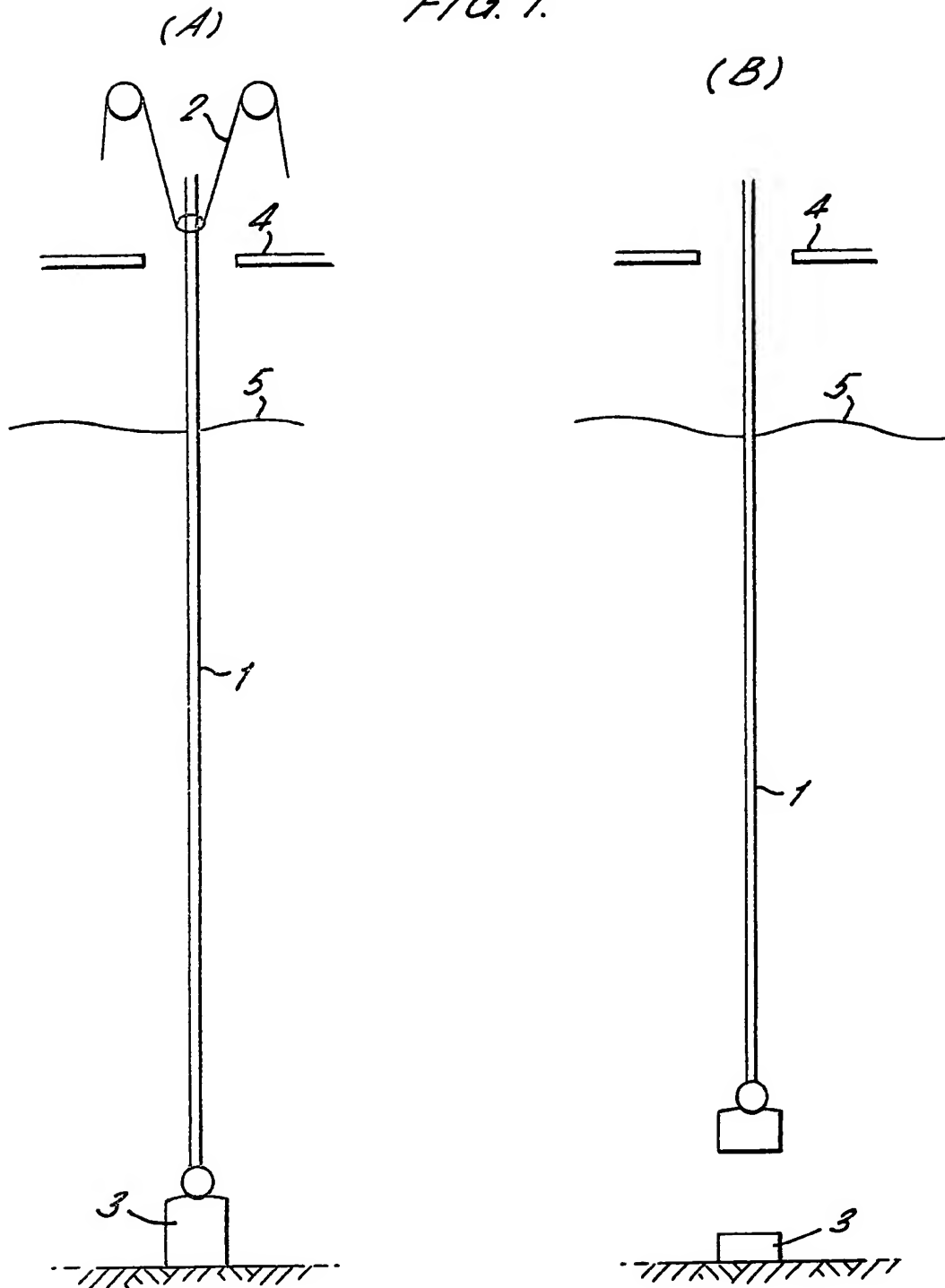
(54) Vessel motion compensation

(57) A vessel having a structure to receive a marine riser (1) comprises a carriage (9) in which the riser is received and in which the riser can slide vertically. The carriage (9) is slidable in one horizontal direction on a further carriage (8) slideable in a transverse horizontal direction on a frame (7) mounted on the vessel deck. The upper end of the riser is held in tension through a tension ring (22) attached to the riser connected by tensioning wires (16) extending over pulleys (14) mounted on a further carriage (13) moveable in one horizontal direction on a further carriage way (12) itself mounted to move in a transverse horizontal direction on frame (11). The wires (16) are connected to tensioners at ends (21). The tensioners take up relative vertical movement between the riser (1) and vessel and permit the vessel to move to a limited extent in any horizontal direction without moving the riser (1) to reduce stressing of the riser due to vessel movement.



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FIG. 1.



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FIG. 2.

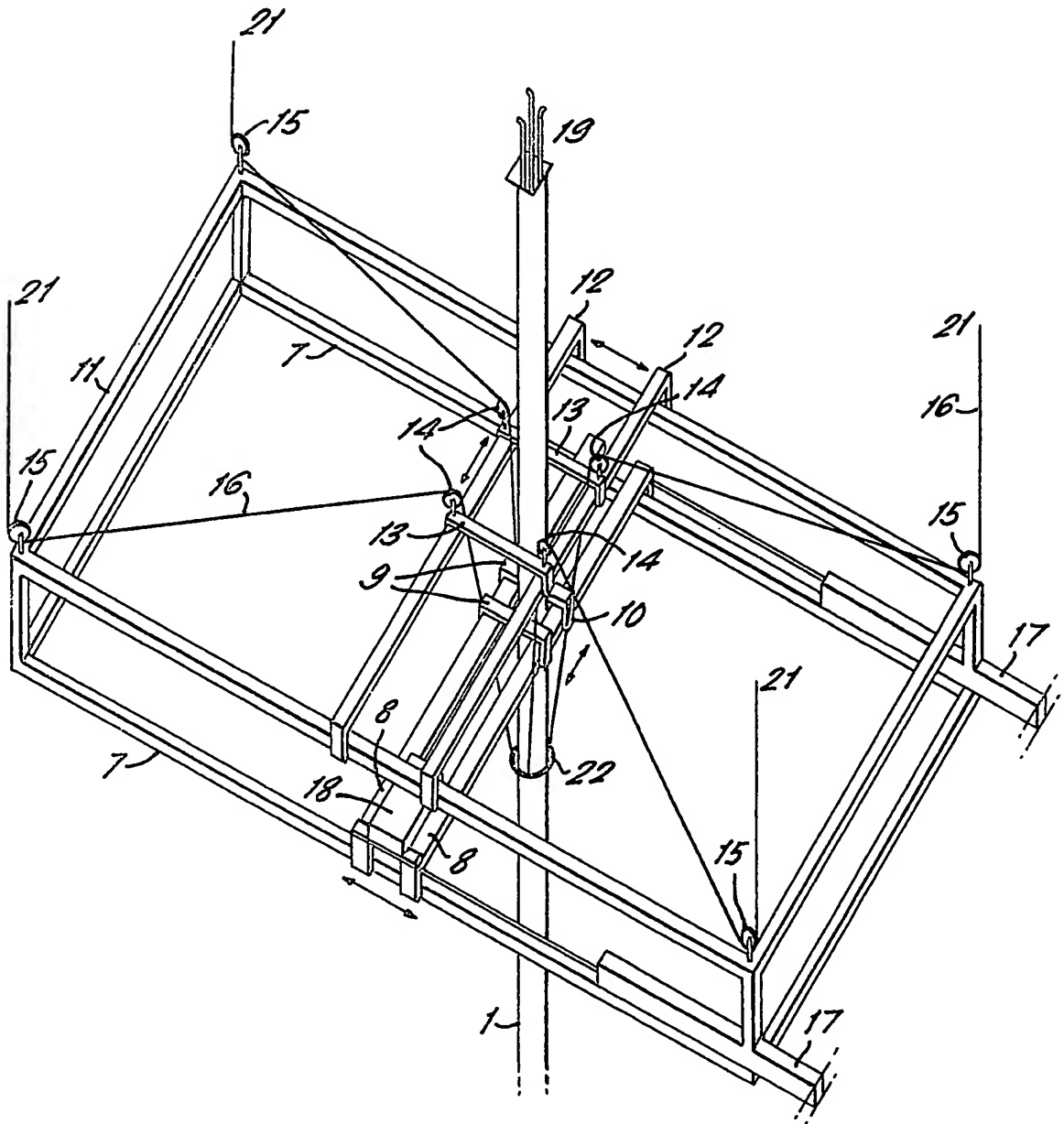
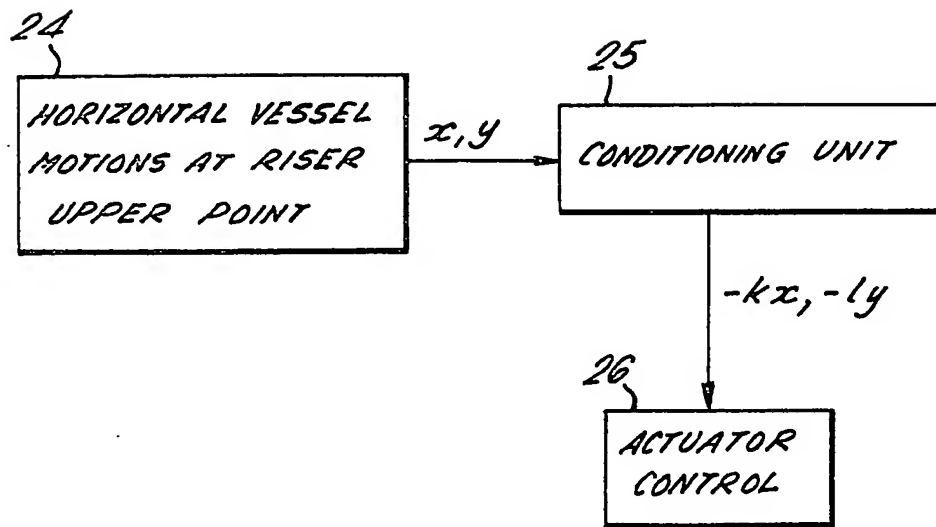


FIG. 3.



SPECIFICATION

Improvements in or relating to marine riser attachments to floating vessels

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This invention relates to floating marine vessels which incorporate a supporting system for marine risers at their upper ends, and is concerned with the reduction of dynamic motions and stresses imparted to the marine riser by horizontal wave induced motions of the supporting surface vessel.

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A marine riser is a long slender steel pipe which connects a subsea well head to a surface vessel carrying out oil drilling or production activities.

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During drilling operations, the marine riser is the conduit through which the drill string (with cutting bit at its lower end) is directed into the sea bed through the subsea well head. The bore of the drill pipe carries a lubricating fluid at high pressure to the drill bit with the annulus between the drill pipe and riser inner wall providing a return path for the low pressure mud and drill cuttings. For oil production operations, the marine riser is almost made up of a number of bundled pipes to carry raw crude up to the platform for processing and to carry the treated crude oil back down to the well head and then to a subsea pipe line or tanker for export.

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Since the marine riser is long and slender (up to 7000 ft long with diameters of 16 to 36 inches) it would buckle under its own weight without a system at its upper end to maintain it in tension. This tensioning system is also designed to take up the relative movement between the surface vessel heaving up and down in waves and the top end of the riser.

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In certain circumstances, usually during the occurrence of a severe storm, the marine riser has to be disconnected from the bottom well head due either to the inability of the tensioner to meet a high stroke requirement or due to the fact that the vessel cannot maintain station above the well head due to high winds and/or currents. Following riser disconnection, the vessel operator has the choice of retrieving the riser assembly, one segment at a time, or of riding out a storm with the riser hanging freely below the vessel without the bottom connected to the sea bed. The former may not be possible because of vessel movement in a severe storm.

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This invention provides a marine vessel having a mechanical assembly to receive an upper end of a marine riser extending from the sea bed in a generally upright direction and guide means both to support the upper end of the riser and to permit limited movement of the riser upper end in any transverse direction to said upright direction to reduce the horizontal movement imparted to the riser end by the vessel due to wind, current or wave action. This vertical relative movement between the attached riser and surface vessel is compensated for by the tensioning system, oscillatory horizontal movement of the surface vessel due to waves induces oscillatory whipping motions of the

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riser pipe material and compensation is made for the relative horizontal movement between the surface vessel and riser. Compensation of the horizontal motion between a floating surface vessel and the upper end of the riser reduces the motions and bending stresses within the riser assembly.

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A tensioned marine riser is subjected to a variety of forces of which the steady components are due to riser self weight, buoyancy as well as internal and external hydrostatic pressures and the drag effects of ocean currents. Unsteady forces due to surface vessel motions and waves are superimposed on the steady forces described above. The unsteady force due to surface vessel motion forms one of the largest perturbations to the riser from the list given above.

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In one embodiment of the invention the riser upper end is completely free to move horizontally relative to the vessel subject only to some practical upper limits to the relative motion about a mean position and to the presence of normal friction forces in the mechanical assembly that may be utilised.

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In another embodiment of the invention the riser upper end is connected to the surface vessel such that relative horizontal motions between the two are governed by a soft spring/damper system with known characteristics. The magnitude of the spring and damping constants can be selected during the design phase or during operation to maximise the reduction in riser stresses.

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Both of the above are passive systems. In a further embodiment of the invention actuators are provided capable of moving the riser upper end so as to negate measured vessel motions and this offers the possibility of greater performance but at the cost of system complexity. The provision of sensors, a control system and actuators needs to be balanced against the likely level of reduction in riser stresses.

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The potential stress reductions available with the above systems have been researched at University College, London using both computer simulations and confirmatory model tests. These show that substantial stress reductions are possible to an extent that may be commercially significant. The stress reductions are such as to reduce the likelihood of riser failure due to overstressing but they also have the additional effect of substantially increasing riser fatigue lives.

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The following is a description of some specific embodiments of the invention, references being made to the accompanying drawings in which:

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Figure 1A is a diagrammatic view of the conventional marine riser support vessel with the riser latched.

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Figure 1B is a similar view of a riser unlatched.

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Figure 2 illustrates an assembly for use according to the invention on a vessel for receiving the upper end of a marine riser.

Figure 3 is a block diagram of a control system.

Figure 1A illustrates the riser, 1, with a tensioner, 2, at the upper end and a subsea well head, 3, at the lower end. 4 denotes the surface vessel deck and 5 is the surface. Note that the tensioner,

2, takes up the relative vertical movement between the riser, 1, and the surface vessel, 4.

If the riser is being hung off, as shown in Figure 1B, the tensioner is locked off and the riser upper end is rigidly connected to the surface vessel by a mechanical gripper.

Figure 2 shows a perspective view of a riser horizontal motion compensation assembly which is capable of providing the means for the solution outlined above.

A straddling carriage 8 is mounted by wheels on both ends (not shown in Figure 2) to a primary frame 7 such that carriage 8 can slide freely in the direction indicated in Figure 2. A smaller wheeled traversing carriage, 9, is mounted on carriage 8 such that it can freely move along 8 in the direction shown. The riser pipe or pipe bundle, 1, is brought up through the central open section of carriage 9 such that the riser is restrained from horizontal motion within the carriage 9 but can slide up and down freely. This feature can be mechanically implemented by the rollers (not shown) within carriage 9.

A secondary frame 11 is mounted some distance above 7 with a similar but larger main carriage 12 and a larger traversing carriage 13. Carriages 12 and 13 can freely move on wheels (not shown) in the directions shown. A set of four travelling pulleys, 14, are mounted on carriage 13 together with four fixed pulleys, 15, mounted on the ends of frame 11.

Tensioning wires, 16, are threaded as shown in Figure 2 from the tensioner end 21, round pulleys 15 and 14 and connected to the riser tension transmitting ring 22.

Note that the frame and carriage assembly (7, 8 and 9) are designed to influence the horizontal motion of the riser only, whereas the frame and carriage denote by 11, 12 and 13 are intended as a follower mechanism for transmitting the vertical tensioner force to the riser. Carriage 13 is wider than 9 in order to enable the tension wires, 16, to bypass 9 for their connection to riser tension ring 22.

During operation of the system, the carriage 13 will follow the horizontal motions of carriage 9 - this feature can be further assisted by running the tension wires through guide rings located on carriage 9.

Flexible lines 19 allow a fluid connection between the riser bore and process systems on board the floating vessel.

The devices marked 17 can be used as spring/damper systems or as actuators to control the motion of carriage 8. Similarly, the device marked 18 can be used to control the motion of carriage 9. Devices 17 and 18 are connected to the respective carriage by pushrods. Alternatively, the devices can contain a rotary chain wheel transmitting motions to 8 and 9 by continuous chains.

The following operational variations can be adopted:

(a) In a fully passive mode, devices 17 and 18 can be dispensed with such that the riser is under very small horizontal restraint due only to mechanical

friction in the carriage wheels, tensioner pulleys and tensioner system.

(b) A further passive mode can be envisaged where devices 17 and 18 contain soft springs and dampers of known characteristics which are such as to act as a vibration absorber between the vessel and marine riser. The required spring rate can be achieved by incorporating mechanical springs or pressurised air within cylinders in device 17 and 18. The required damping contribution can be obtained from an oil filled dash pot system also within device 17 and 18 or by utilising forced oil flow through orifices. A number of other systems can be devised to generate the required spring rates and damping values.

(c) An active mode of operation for the system shown in Figure 2 requires the use of actuators in place of devices 17 and 18. These actuators under the control of a system such as that shown in the block diagram of Figure 3 would operate to negate horizontal vessel motions sensed by monitoring unit 24. The signals from 24 would be sent to a conditioning unit 25 whose function would be to scale the signals from 24 appropriately and to negate the sense of the signals so as to operate the actuators, 26, in the opposite sense in order to compensate for vessel motions.

The vessel motion compensation system described above has been shown to be feasible through the use of computer based simulations describing its performance. The simulation results have been confirmed by model tests.

The compensation system yields a significant reduction in riser stresses due to its operation. These stress reductions are sufficiently large to make the compensation system of commercial value.

CLAIMS

1. A marine vessel having a holder to receive an upper end of a marine riser extending from the sea bed in a generally upright direction and guide means both to support the upper end of the riser and to permit limited movement of the riser upper end in any transverse direction to said upright direction to reduce the horizontal movement imparted to the riser end by the vessel due to wind, current or wave action.

2. A marine vessel as claimed in claim 1 wherein a first guideway is mounted on the vessel extending in one horizontal direction, a first carriageway is mounted for movement along the guideway, a second guideway is mounted on the first carriage and extending in a second horizontal direction transverse to the first guideway and a second carriage is mounted on the second guideway for movement along the second guideway and to receive the upper end of the marine riser.

3. A marine vessel as claimed in claim 2 wherein the first guideway comprises a first pair of parallel rails horizontally spaced apart with end stops and the first carriage is mounted on the rails for movement along the rails between the end stops.

4. A marine vessel as claimed in claim 3

wherein the second guideway comprises a second pair of horizontally spaced rails on the first carriage and extending between and generally transverse to the first pair of rails and the second

5 carriage is mounted for movement along the second pair of rails.

5. A marine vessel as claimed in any one of the preceding claims wherein the guide means include means for biasing the marine riser to a central
10 position in its range of permitted movement in said directions transverse to the upright direction of the riser.

6. A marine vessel as claimed in claim 5 wherein the means for biasing the riser to said
15 central position is constructed to provide progressively increasing resistance to movement of the riser away from said central position in any transverse direction to said upright direction.

7. A marine vessel as claimed in any of claims
20 1 to 4 wherein guide means includes spring/damper devices for restraining the movement of the carriages along the rails in any direction.

8. A marine vessel as claimed in any of claims
1 to 4 wherein control means are provided for
25 moving the guide means with respect to the vessel to maintain within the limited range of movement provided for the guide means the upper end of the marine riser in a fixed position notwithstanding horizontal movement of the vessel.

30 9. A marine vessel as claimed in claim 8 and in the case where the guide means include first and second carriages movable along first and second transversely extending guideway wherein a control means comprise actuators for moving the car-
35 riages along the guideways to compensate for movement of the vessel.

10. A marine vessel substantially as described with reference to and as illustrated in the accompanying drawings.

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